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The effect of electric field on the operation of a photoresistor induced by He-Ne laser

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Abstract The effect of electric field on the operation of the photoresistor that is sensitive for visible range of electromagnetic spectrum has been studied in this work. Electric fields with varied intensities have been applied to the photoresistor and relationship between the applied electric field and the resistivity of the photoresistor in dark ambient has been obtained. Secondly, during the experiment, incident He-Ne laser light flux on the surface of the photoresistor has been kept constant and applying electric field E_{dc} which increases gradually from 0 up to 2.5×10^5 V/m on the semiconductor substance the relationship between the resistivity of the photoresistor and the applied electrical field has been studied. At the end, typical response curves related to photoresistor have been obtained.

Keywords Photoresistors, electric field, He-Ne laser

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Photoresistors have recently been used in the optoelectronics applications. These electronic components are sensible for different ranges of electromagnetic spectrum depending on the materials. Changing the materials and doping substances, spectral sensitive range of the photoresistors can be changed. The photoresistors used significantly in the industry [1] are CdS (λ_{max} 0.51 μm) [2], ZnS (λ_{max} 0.34 μm), GaP (λ_{max} 0.55 μm), GaAs (λ_{max} 0.87 μm) Si (λ_{max} 1.1 μm) and also Ge (λ_{max} 1.8 μm) [3,4,5]. These have been produced by different deposition techniques [6] such as physical evaporation and chemical depositions on the substrates [7]. In the production of the photoresistors which are sensitive for visible range, CdS [8] have mainly been used and doping different substances such as rare earth elements [9], the sensitive range of the semiconductor component has been changed [10]. Using carbon electrodes in the production of the photoresistor, low contact resistance has been obtained [11] and utilising the suitable technique, smoothness of the gradient of the applied electric field has been achieved. Improving these photoresistors based on CdS, they can be used in X-ray dosimetry [12]. Meanwhile, in the operation of the photoresistors, external parameters such as the effect of temperature change and deviation of incident light flux have been playing significant role. Lattice temperature and thermal velocity of the electron in the crystal increases when an electric field E_{dc} is applied on any semiconductor crystal and also there is a direct proportionality between the applied electric field E_{dc} and the resistance of the photoresistor. Concerning the working conditions of the photoresistors, as illumination on the device increases in intensity, the energy state of a larger number of electrons in the structure of the photoresistor will increase as well, because of the increased availability of the photon packages of energy. The result is an increasing number of relatively free electrons in the structure of the photoresistor and a decrease in the terminal resistance of the device [3]. With no incident light, the cell resistance is maximum, this is called dark resistance. As the light intensity increases, the resistance decreases significantly [2]. In this work, varying the intensity of the electric field E_{dc} that from 0 to 2500 V_{dc}, typical response curves have been obtained by experiment.

In the experiment, constant light intensity on the photoresistor was kept in an ambient. The electric field E_{dc} was applied for the photoresistor. In the second step, keeping the light intensity of the ambient of the photoresistor to be constant, the surface of the photoresistor was illuminated by He-Ne laser and the electric fields were varied.

The experimental data obtained in this work has been shown in Table 1. Typical experimental data has been obtained and the graph of the obtained data is shown in Figure 1. Two significant curves have obtained, in one the relative resistance of the photoresistor in dark ambient and

Table 1. Change in the resistivity of the photoresistor with the intensities of electric field E_{dc}

Applied voltage (V_{dc})	Intensity of electric fields E_{dc} between two plates (V/m)	Relative resistance of the photoresistor at dark ambient (Ω_{max}/Ω)	Relative resistance of the photoresistor induced by He-Ne laser (Ω_{max}/Ω)
0	0	1	1
500	5×10^4	0.44	1.33
1000	1.0×10^5	0.24	1.6
1500	1.5×10^5	0.173	2
2000	2.0×10^5	0.11	4
2500	2.5×10^5	0.078	16

a nonlinear regression curve of the data has been obtained. In the second one, the data obtained from that of relative resistance induced by He-Ne laser and also the relevant nonlinear curves have been obtained and results are seen in Figure 1.

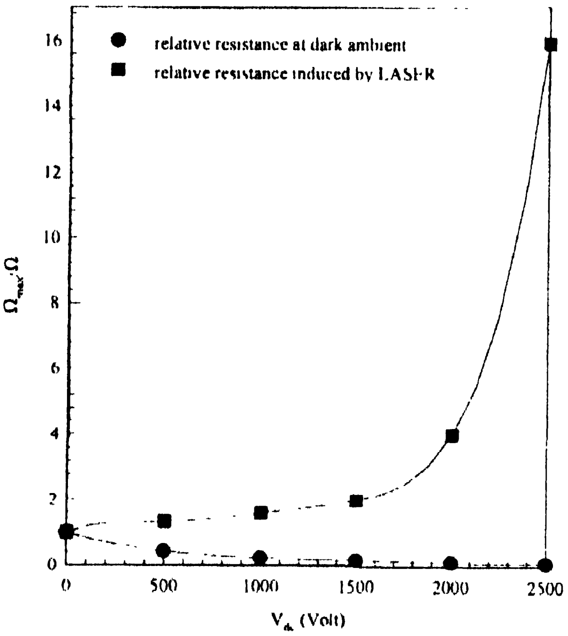

Figure 1. The relative resistance of the photoresistor at various intensities of electric field E_{dc} in dark and in the photoinduced ambient

In this work, the behaviour of the photoresistor in dark and in laser-induced ambient at various intensities of electric field E_{dc}, have been studied and two original curves have been obtained. While resistivity of the photoresistor *versus* incident light curve changes linearly, it has been seen that with and without He-Ne laser, relative resistivity of the photoresistor *versus* electric field E_{dc} curve changes nonlinearly. As a conclusion, it is thought that these nonlinearities in the behaviour of the photoresistor may have originated from by the nonlinearity of the internal parameters such as drift, mobility in the semiconductor crystal affected by the electric field E_{dc}.

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